United States
Department of
Agriculture

Soil
Conservation
Service
Phoenix
Arizona

FLOOD PLAIN MANAGEMENT STUDY
for the
PALOMINAS-MIRACLE VALLEY AREA
Cochise County, Arizona

Prepared by the

United States Department of Agriculture
Soil Conservation Service
In cooperation with the
Hereford Natural Resource Conservation District
Cochise County
Arizona Department of Water Resources

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INTRODUCTION

Study Request

On September 20, 1983 the Hereford Natural Resource Conservation District (NRCD) first requested assistance from the Soil Conservation Service, USDA, to assess flood problems and evaluate opportunities to alleviate them. Problems experienced by the Palominas School complex were of particular concern. In response, field examinations and preliminary data were gathered for this area in February 1984. The study was then placed in priority with other requests.

The Cochise County Board of Supervisors have supported the study and the Arizona Department of Water Resources have given their endorsement.

The need for this study was prompted by (1) flooding of the Palominas School, (2) flood related problems in the Miracle Valley subdivisions and (3) the lack of sufficient detailed flood information to define the hazards and examine possible solutions. Although there is flood insurance data available, all mapping and related studies were performed by approximate methods (Reference 1).

Local Input

The Hereford NRCD has provided general information and assistance in gathering some field data. They conducted a public meeting on November 21, 1985 to inform the community of the purpose of this work and to solicit information pertinent to the study.

Cochise County participated by paying part of the cost of aerial mapping. The office of the Flood Plain Administrator has gathered building value and height from ground-to-first floor level data to enable damage analyses to be performed.

Local people have contributed information on the history of the community and concepts that might be applied to reduce flood hazards.

Authorities

A plan of work was developed, approved and signed by the sponsors and endorsers in August 1985. On August 29, 1985 the National Headquarters of the Soil Conservation Service formally authorized the performance of the study.

Federal authorities for these studies are set forth in Section 6, Public Law 83-506, Watershed Protection and Flood Prevention Act. Another authority is presented in Executive Order 11988, Flood Plain Management, Section 1, with regulations contained in 7 CFR 650.25. The regulations instruct federal agencies, regarding their responsibilities, to avoid the risk of flood loss, minimize impacts and to restore and preserve the natural and beneficial values served by flood plains. A Unified National

Program for Flood Plain Management, Water Resources Council, September 1979, provided for the acceleration of flood plain studies to assist state and local users.

Arizona Revised Statutes require communities to delineate and manage flood plains (ARS 48-3609). Subsequent to these statutes, Cochise County has adopted "Floodplain Regulations for Cochise County, AZ," July 1984. The regulations include the purpose "1.3(7) to contribute toward informing of potential buyers that property is in an area of special flood hazard; and 1.3(8) to inform those persons within areas of special flood hazard of such designation and applicable requirements".

Technical Procedures

Detailed hydraulic and hydrologic analyses were made of all flow paths within the study area. The detailed results are presented only for those reaches of channel considered to have sufficient accuracy.

Procedures included developing data with field investigations and aerial mapping techniques. The data were used in the Corps of Engineers' HEC-2 computer program to calculate water surface profiles (Reference 2) and in the SCS TR-20 Rainfall-Runoff Model (Reference 3) to compute flood flow-frequency relationships.

Reliability of Results

Despite the application of detailed methods, these areas of shallow flooding (less than one foot) are not well defined. The nature of the shallow, shifting, ill-defined flow paths on the alluvial plain makes it

extremely difficult to define flood boundaries with a high degree of accuracy. These features are compounded by man-made barriers and diversions such as streets, ditches, low berms, fences, buildings, etc. that make definition of flood boundaries extremely difficult if not impossible. These conditions require that the flood plain boundaries and flood depth estimates at specific points be interpreted and used with caution.

STUDY AREA DESCRIPTION

Location

This study area is located in the extreme southeast part of Arizona, about four miles from the United States-Mexico border. It lies in the southwest part of Cochise County, approximately 15 miles west-southwest of Bisbee and 17 miles southeast of Sierra Vista. Much of the drainage area lies parallel to Highway 92. Refer to Figure 1.

The watershed is part of the San Pedro River Basin in the Lower Colorado River Region and its hydrologic unit number is 15050202040.

Settlement History

This land was part of that purchased from Mexico under the Gadsden Treaty in 1854. The settlement of this area progressed rapidly after this treaty. The area was opened to homesteading in the late 1890's and early 1900's.

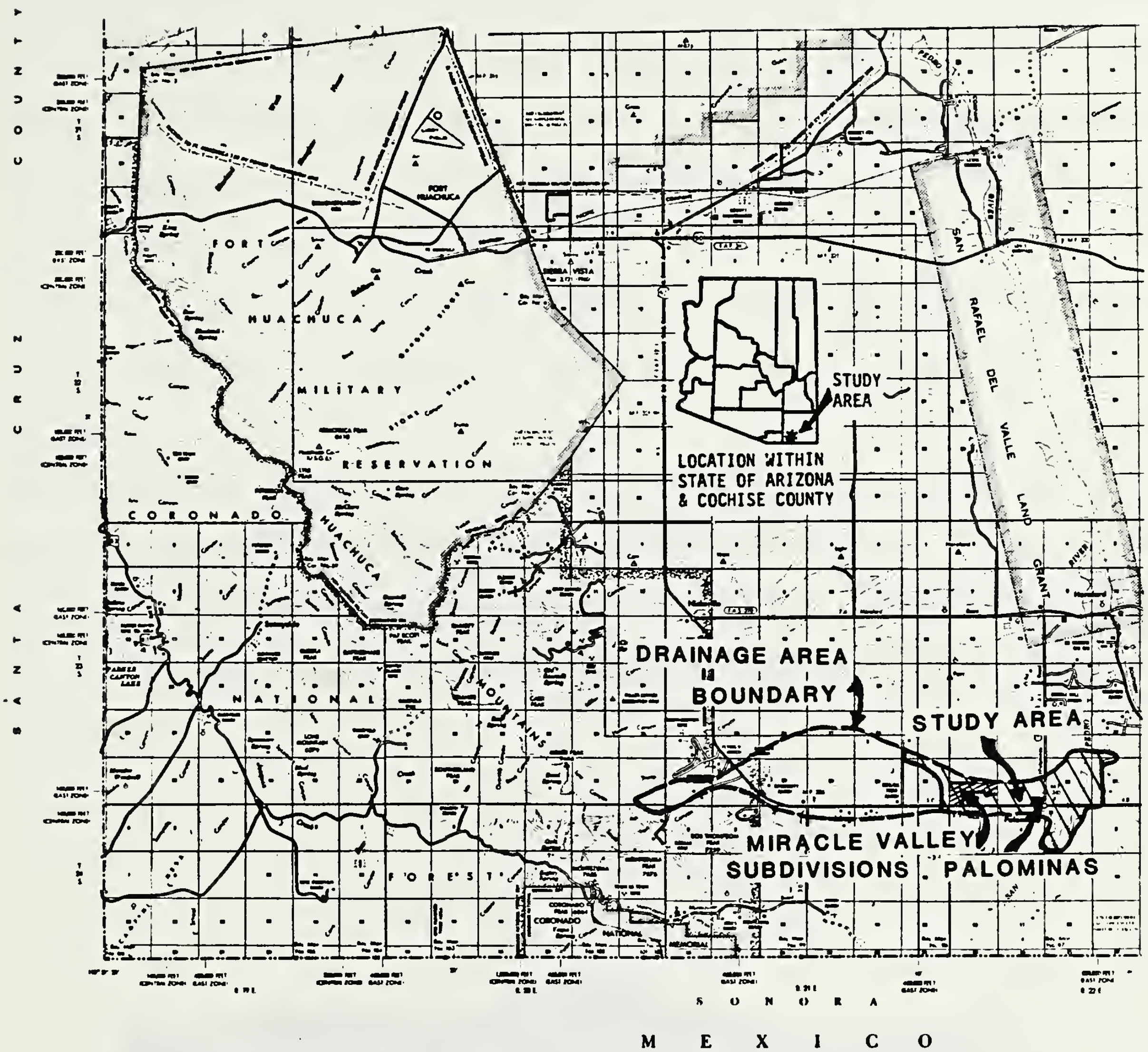


Figure 1
Location Map

Originally Palominas was an early border custom station. It was used extensively by travelers going between Mexico and the United States following a route along the San Pedro River. This station was later abandoned and the name was taken for a school built on two acres of land donated by the early homesteaders, which is the present Palominas School site (Reference 4).

In the late 1950's a local landowner donated 320 acres of land to A.A. Allen Revival Inc. which was later named Miracle Valley. Then in the early 1960's another 320 acres north of Highway 92 were subdivided and sold as homesites. It is this latter area that is designated as Miracle Valley Subdivisions (Reference 5).

The two communities are unincorporated and under the jurisdiction of Cochise County. The 1980 census shows a population of 930 people.

Climate

The study area (mapped area) lies within the elevation range of 4210 feet to 4370 feet above the National Geodetic Vertical Datum (in the lower part of the San Pedro River Valley adjacent to the river.) The watershed heads in the Huachuca Mountains at an elevation of about 6000 feet. Refer to Fig. 2.

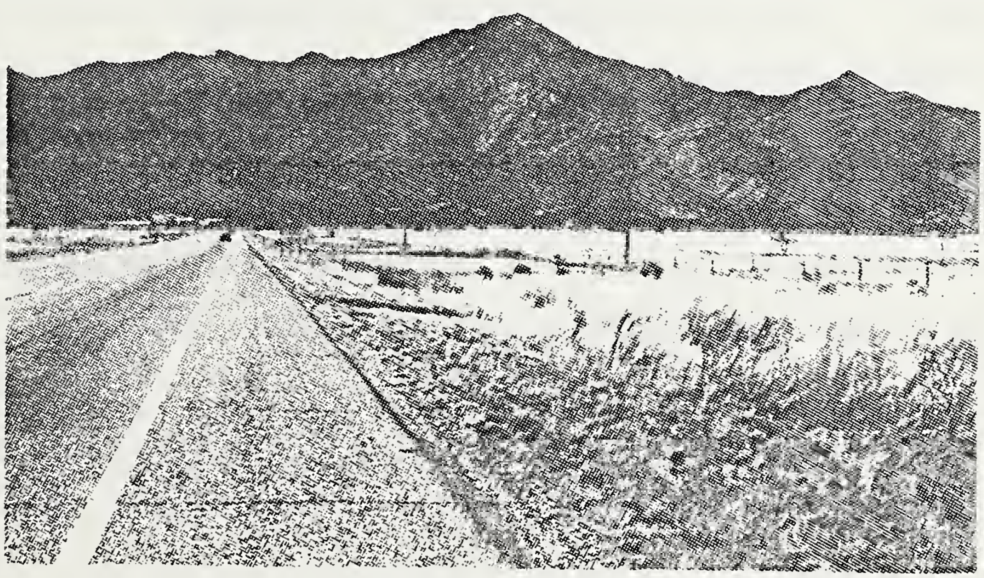


Figure 2
The Watershed Heads in the Huachuca Mountains

In the summer, warm moist air moves in from the southeast. Under the influence of strong surface heating and orographic uplift, numerous showers and thunderstorms develop, usually during the afternoon or evenings. Although the showers are brief, some are intense and cause the most severe flooding of the area of concern. More than 65 percent of the annual precipitation of 14 inches occurs during the summer season.

Precipitation during the other seasons is usually associated with middle latitude cyclonic storms from the Pacific Ocean. The frequency and intensity of these storms is greatest about mid-winter. The fall and winter seasons account for about 18 and 14 percent, respectively, of the total annual precipitation.

Spring is the driest, windiest and dustiest season, producing an average of only three percent of the total precipitation.

Temperatures are comparatively mild throughout the year. In summer the elevation of the area and the high frequency of cloudiness combine to keep the afternoon temperatures down. The average July temperature is about $75^{\circ}F$. In winter the temperatures tend to be slightly cooler than surrounding areas due to the colder, more dense air flowing along the low point in the valley. The average January temperature is about $45^{\circ}F$.

The area receives more than 80 percent of all possible sunshine.

Soil Resources

The major soils in the study, or mapped area, consist of the Forrest clay loam and the Diaspar sandy loam soil mapping units.

The Forrest clay loam profile, typically, has a surface layer of dark brown clay loam about seven inches thick. The subsoil is reddish brown clay about 30 inches thick. The substratum, to a depth of 60 inches or more, is light brown clay loam. In some areas the surface layer is sandy clay loam or silty clay loam. The infiltration rate is slow and, therefore, this soil has a moderately high runoff potential.

The Diaspar sandy loam mapping unit profile is typified with a surface layer of brown sandy loam about six inches thick. The subsoil is reddish brown sandy loam about four inches thick. The underlying layer to a depth of 60 inches or more is brown sandy loam. In some areas the surface layer is loam. This soil has a moderate infiltration rate and, consequently, a moderately low runoff potential.

The major soils in the area contributing runoff into the study or mapped area includes the two soils described above along with the Forrest-Gadwell complex and Saddlegap cobbly loam.
The Forrest mapping unit associated with this complex has a typical profile described with a surface layer of strong brown fine sandy loam about three inches thick. The upper three inches of the subsoil is strong brown gravelly clay loam. The lower part, to a depth of 22 inches, is dark red and red clay. The underlying material, to a depth of 60 inches, is reddish brown and strong brown calcareous clay loam.

The Gadwell portion of this complex has a typical profile with a surface layer of strong brown gravelly sandy loam about four inches thick. The upper part of the subsoil is strong brown gravelly clay loam about six inches thick. The lower part, to a depth of 26 inches, is yellowish red and red very gravelly clay. The underlying material to a depth of 60 inches is dark red very gravelly clay.

The infiltration rate of this complex is slow and, therefore, the runoff potential is moderately high.

The Saddlegap cobbly loam unit typically has a surface layer of dark brown cobbly loam about four inches thick. The subsurface layer is reddish yellow very cobbly loam about 15 inches thick. The subsoil is yellowish red very cobbly and cobbly clay to a depth of 60 inches. This soil has a moderate infiltration rate and, therefore, a moderately low runoff potential.

Drainage Areas and Stream Lengths

The study area was subdivided into four areas for analysis purposes. The four are listed below along with the total drainage area and length of streams mapped:

Subarea	Drainage Area (Mi^2)	Stream Length (Miles)
School House Wash	6.87	4.22
Miracle Valley Palominas	1.04	9.81
South of Highway 92	1.30	3.35
San Pedro River	741. 1/	2.65

1/ Taken from US Geological Survey Water Data Reports

Upland Vegetation and Land Use

Approximately 4900 acres of land lies above the study (mapped) area. This is about 80 percent of the total area. The major land use is livestock grazing.

This upland area includes the following land ownership, in terms of percent of total area:

National Forest	8%
Bureau of Land Management	11%
Private	61%

The vegetation in these areas include the following:

Plant Group	Types	Percent
Grasses	Lehmans Lovegrass, Blue Grama, Black Grama, Side Oats Grama, Plains Lovegrass	85
Shrubs and Trees	Shrub Oak, Manzanita, Large Oak, Juniper, Mesquite	11
(Non Range)	Ranch and Farm headquarters	4

Study Area Vegetation and Land Use

About 1200 acres lies within the study area, above and excluding the San Pedro River area, or 20 percent of the total. The major land uses in this part include residential developments (including houses, schools, some commercial establishments) and farmland. This makes up about 12 percent of the total. Range land uses make up the remaining 8 percent of the total.

The land ownership of this part includes private, 18 percent of the total, and Bureau of Land Management, two percent.

The vegetation in the study area includes:

Plant Group	Types	Percent
Grasses	Blue Grama, Side Oats Grama, Grass, Tabosa	39
Forbs	Telegraph Weed	1
Shrubs and Trees	Mesquite, Rabbit Brush, Cottonwood	1
(Non Range)	Residential Developments	59

NATURAL FLOOD PLAIN VALUES

Prime Farm Land

There is a total of about 850 acres of prime farm land within the study area. Refer to map in back of report. The 100-year flood is expected to inundate about 69 percent of this, or 590 acres. This includes about 285 acres along the San Pedro River and the balance, 305 acres, along the drainages from the west.

Land Uses in the 100-year Flood Plain

The 100-year flood is expected to inundate about 740 acres from the western streams on the alluvial plain and 540 acres along the San Pedro River or a total of 1280 acres. About 12 percent of this area is occupied by residential, school, or commercial developments; 38 percent is actively farmed and 50 percent is either used for rangeland grazing or is abandoned farmland.

Wildlife Resource Areas

Following is a description of the vegetation and land use within the study area as they relate to natural values, especially wildlife resources. Refer to the associated map in back of the report.

Riparian Area (San Pedro River)--This area includes the riprarian vegetation growing along the San Pedro River. The most important of these include cottonwood, black willow, seep willow and mesquite. This is the most important wildlife habitat in the study area. Water, cover, roosting, nesting and food components of habitat are available. Annual and perennial forbs are abundant along the edges of the trees.

Cropland (Actively Farmed)--This land is being irrigated and produces mainly grass and alfalfa pastures and small grains. Several large ponds provide waterfowl resting and nesting areas.

Abandoned Cropland (Presently Idle)--These lands appear to have been abandoned or idle for several years. Native and exotic grasses and forbs are invading.

Rural Built-up Land--These areas have houses, schools, barns, roads, commercial businesses, etc. They contribute little to wildlife habitat although some nesting is available in landscaped areas.

Native Rangleland--This land does not appear to have ever been developed for farmland. Rubber rabbitbrush, prickly pear, telegraph weed, blue grama, tabosa grass and sideoats gramma predominate. These areas provide sanctuaries for the less mobile forms of native wildlife.

Except along the San Pedro River there is not much good wildlife habitat in the flood plain areas. The large farm ponds and some landscape plants are the only locations to attract the more mobile animals such as javelina, birds, deer, raccoon, badger, etc. These animals will naturally move to the riparian zones along the river.

There were no historic nor prehistoric sites found in the field surveys.

FLOOD PROBLEMS

Flood History

Flooding from School House Wash poses the greatest hazard to the Miracle Valley Subdivision. The land occupied by the Palominas School has been repeatedly inundated with floodwater coming from local runoff traveling parallel to and north of Highway 92 and from School House Wash, but only once has water gotten into the buildings. The last large flood occurred in the summer of 1983 and caused damage to three residences in the Miracle Valley Subdivisions.

The most recent flood on the San Pedro River was in October 1977, but only minor damage was inflicted. The highest flood stage was noted in September 1928 and the largest measured flow of 22,000 cfs occurred in August 1940.

Local people have not kept a flood history of the area, but older residents point out that flooding has been a problem for a long time. As noted by the high floor on the only original school building remaining, shown in Figure 3, special provisions were made to elevate the lower floors of the buildings.

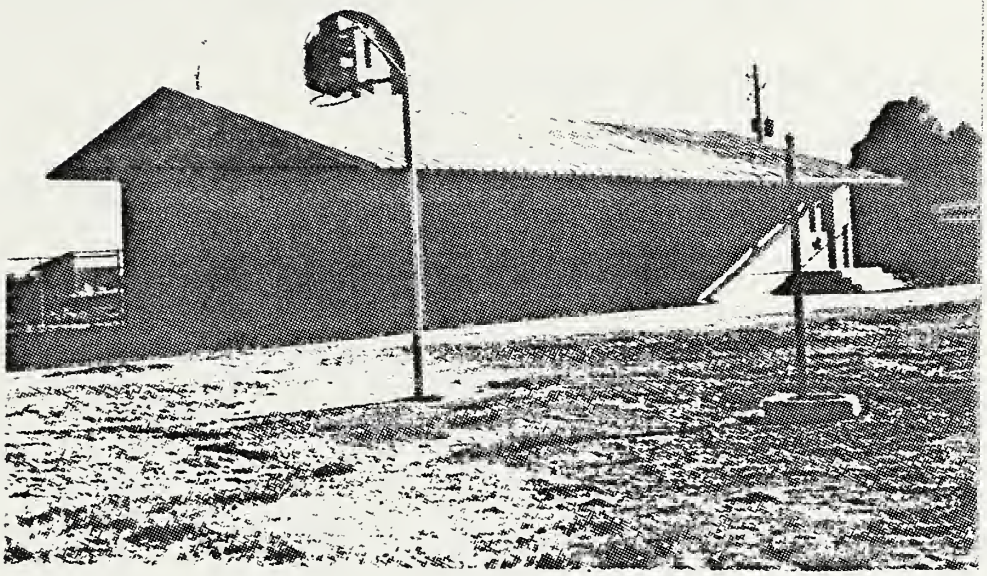


Figure 3
Floor in Early School Building Elevated for Flood Protection

Area Inundated by the 100-year Flood

Study results show that the 100-year flood can be expected to cover the following areas:

Stream Area	Flooded Area by Land Use (acres): Residential, School Commercial	Farm Land	Abandoned Farm Land/ Range Land	Total
School House Wash	50	80	190	320
Drainage Parallel and N. of Highway 92	50	0	170	220
Drainage Parallel and S. of Highway 92	10	120	70	200
San Pedro River	40	290	210	540
TOTAL	150	490	640	1280

Properties Affected and Estimated Damage by the 100-Year Flood

Stream/Area	Houses	Mobile Homes	School Buildings	Storage Buildings	Total
	Number of Properties Flooded by Type				
School House Wash	8	5		11	24
Drainage Parallel and N. of Highway 92	12	-	3	12	27
Drainage Parallel and S. of Highway 9	1	-	-	1	2
TOTAL	21	5	3	24	53

The 100-year flood damages to buildings and their contents are estimated to amount to $86,100. The average annual damage is estimated to be $17,700.

For this study, damage to properties caused by flooding from the San Pedro River was not determined.

EXISTING FLOOD PLAIN MANAGEMENT

State and Local Regulations

Arizona Revised Statutes 48-3601 through 48-3627 pertain to flood plain management and flood control. ARS 48-3602 directs each county to organize a flood control district to include and govern its area of jurisdiction. The statutes direct the flood control district board to "....delineate or may by rule require developers of land to delineate for areas where development is

ongoing or imminent, and thereafter as development becomes imminent, flood plains consistent with the criteria developed by the director of water resources". They further require the board to adopt and enforce regulations governing flood plains and flood plain management.

Subsequent to the state legislative establishment of the statutes, referred to above, Cochise County selected a flood plain board. Under their direction flood plain regulations were drawn up and approved in July 1984 (Reference 6). The regulations specify that a flood plain use permit be obtained before construction or development begins within any area of special flood hazard (defined as land in the flood plain within a community subject to a one percent or greater chance of flooding in any given year). The permit is reviewed by the Floodplain Administrator. This is the major vehicle to regulate and manage flood plain areas.

Structural Efforts

A channel was constructed along the northern edge of the Miracle Valley subdivisions to convey School House Wash by the development. Construction of this channel was apparently done with little advanced planning and design. Consequently, the channel decreases in carrying capacity as it proceeds eastward. Refer to Figures 4, 5 and 6.

Figure 4
School House Wash near Loaves and Fishes Drive
Maximum Capacity about 1900 cfs

Figure 5
School House Wash Near Deliverance Way Drive
Maximum Channel Capacity about 600 cfs

Figure 6
School House Wash Upstream from Dip Crossing
Maximum Capacity about 200 cfs

A pond was also constructed near the east boundary of the subdivisions on School House Wash. The intent of the pond is unknown and has since filled with sediment and become obliterated.

Water spreading structures have been installed on the land between the Miracle Valley Subdivisions and Palominas School. Although their purpose is to spread the water out to increase plant production for grazing they also serve to disperse flood flows.

Palominas School has added some flood proofing features to the buildings. Refer to Figure 7. Some low dikes and walls have been put up to protect houses, refer to Figure 8.

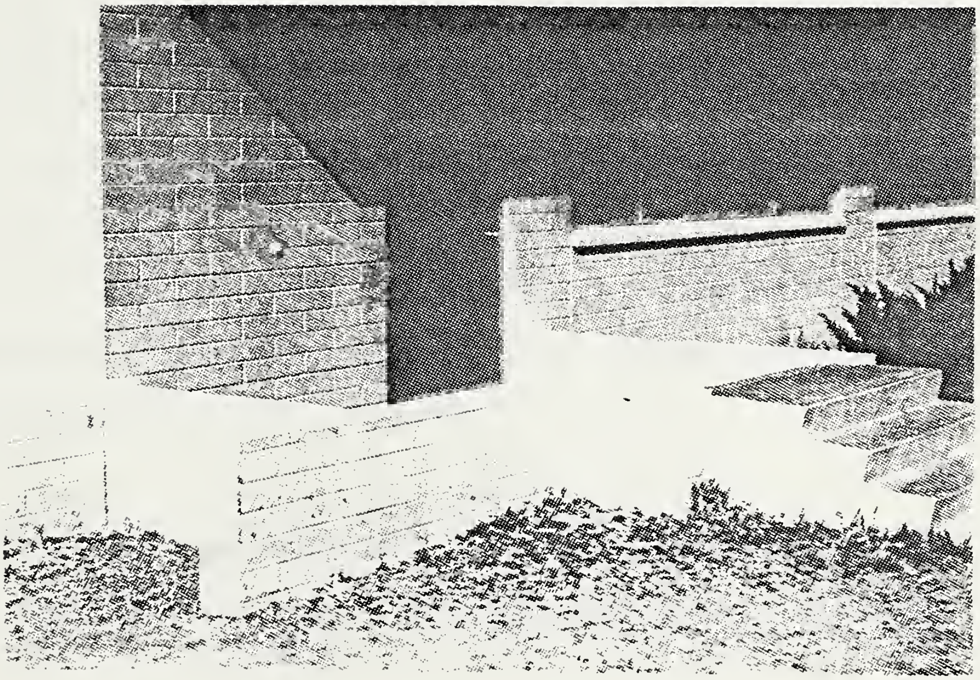


Figure 7
Flood Proofing Junior High Building, Palominas School

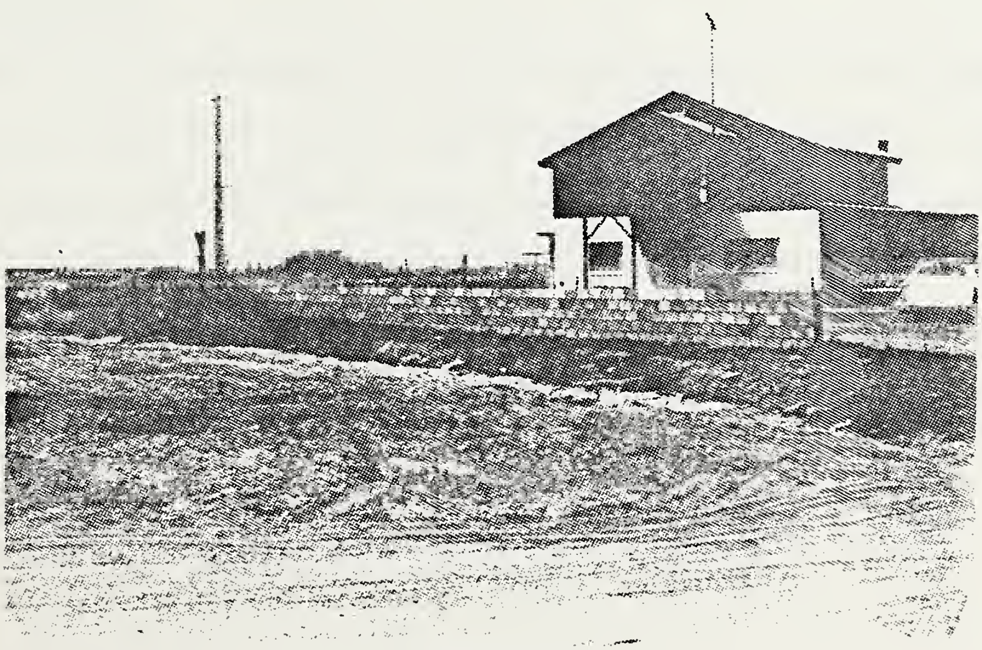


Figure 8
Flood Proofing of House North of and Adjacent to School House Wash

The state highway department has installed several short training dikes to divert flood water away from the highway road bed.

Public Participation

On November 21, 1985, a public participation meeting was held at the Palominas School library. This meeting, conducted by the Hereford NRCD, was held to explain the purpose and procedures of this study. The public was asked for any flood history and related data and invited to recommend flood plain uses and management alternatives that might be considered in the study and possibly adopted by the flood control district.

Those in attendance included members of the Hereford NRCD Board, the Cochise County Floodplain Administrator, SCS personnel and local citizens.

ALTERNATIVES FOR FLOOD PLAIN MANAGEMENT

Present Condition

The study area has experienced slow growth since the initial development of the Miracle Valley subdivisions. The Palominas School complex has recently added a special education building and plans to construct additional classroom buildings to handle an increase of students. The increase is coming from the Moson Road area to the north (outside) of the study area. Some of this growth may spill over into the study area, but no significant amount is expected within the near future.

Land Treatment

Limited land treatment has been applied in the upland areas in the past. Land ownership patterns and noninterest has delayed proper treatment of these lands. One land owner has applied proper use practices and installed water spreading structures that have improved the vegetative cover and dispersed the flood flows over his rangeland.

Improving ground cover to reduce runoff has a good potential in much of the upland runoff contributing areas since a large portion of the area is open grass rangeland. Such practices as deferred grazing, planned grazing systems, proper grazing use, range seeding and water spreading practices, either by way of combinations or individually, offer a means to increase plant growth quality and quantity.

Supplemental practices including installing grassed waterways and grade stabilization structures could aid in controlling runoff and reducing erosion.

Such treatment and land care, described above, could reduce runoff volumes and rates and, consequently, decrease downstream flooding and erosion.

Preservation and/or Restoration of Natural Values

The better farmland and major part of the prime farmland is located near the river. Soils have higher contents of rocks and gravels as one proceeds toward the upland areas. The prime farmlands should be reserved for crop production. Water limitations and economic return are the largest factors that affect maintaining these areas in crop production.

Increasing plant growth in the upland areas could also increase habitat for wildlife resources, but it is obvious that the preservation of the wildlife habitat components along the San Pedro River should have the highest priority. The riparian zones along the river provides, by far, the best wildlife habitat in the study area.

Any planned developments or construction of any kind should carefully avoid or mitigate these natural resources.

Nonstructural Measures

The primary objective of this study report is to meet the need of informing all readers of the flood hazards existing within the study area. This information should be made available to the public, especially those now residing in the area and those who propose to build within the area. Therefore, this report should serve as an important nonstructural means of reducing flood damages.

Flood insurance can be purchased by those who now have buildings within the flood plain. Insurance policies may be purchased from any property and casualty insurance agent or broker licensed to do business within the state. For the most part, insurance costs will be relatively low due to the shallow flood depths.

For those areas not now containing buildings, land use and control measures can be carried out by the existing flood plain regulations for Cochise County. The flood plain use permit system should result in protecting potential builders as well as the people now residing in the area. Flood proofing, elevating, setback, anchoring and other requirements set forth by the existing ordinances can effectively reduce damages to future developments.

Since the flood plain is on an alluvial plain with ill defined and varying flow paths, there are few areas that can be considered free of flood hazards. Therefore, flood proofing of individual buildings probably offers the most expedient way to attain protection. This can best be obtained by elevating the lowest floor of any new building. Existing buildings can be protected by sealing unused openings, applying sealants to walls and floors, constructing fences, walls or berms, lowering streets, etc. Great care must be taken when installing such things as fences, walls, or berms, the lowering of streets or any other measure that might alter the direction, amount or velocity of the flood flows because of potential adverse effects on downstream properties.

A flood warning system could work very effectively on the San Pedro River because of the size of the drainage area and travel time of a flood. The travel of a flood wave could be tracked carefully with the proper monitoring system. Complications are raised since most of the drainage area at Palominas lies in Mexico. A flood warning system on the local drainages is not very practical because of the short response time between imminent flooding and arrival of the flood.

Structural Measures

Since individual efforts can often produce adverse impacts on adjacent and downstream areas the installation of a well planned and designed system will attain the most effective control.

This study considered a structural system containing five components. Referring to the map, Figure 9, these components consist of (1) a floodwater diversion above and parallel to Healing Way Road; (2) enlargement of School House Wash through the Miracle Valley subdivisions; (3) Palominas School dikes; (4) dikes extending from Palominas Road to the San Pedro River and (5) a flood channel parallel to Highway 92 conveying water past the Palominas School to the San Pedro River. Each of these components was evaluated on the basis of controlling the 100-year flood and is briefly discussed in the following sections.

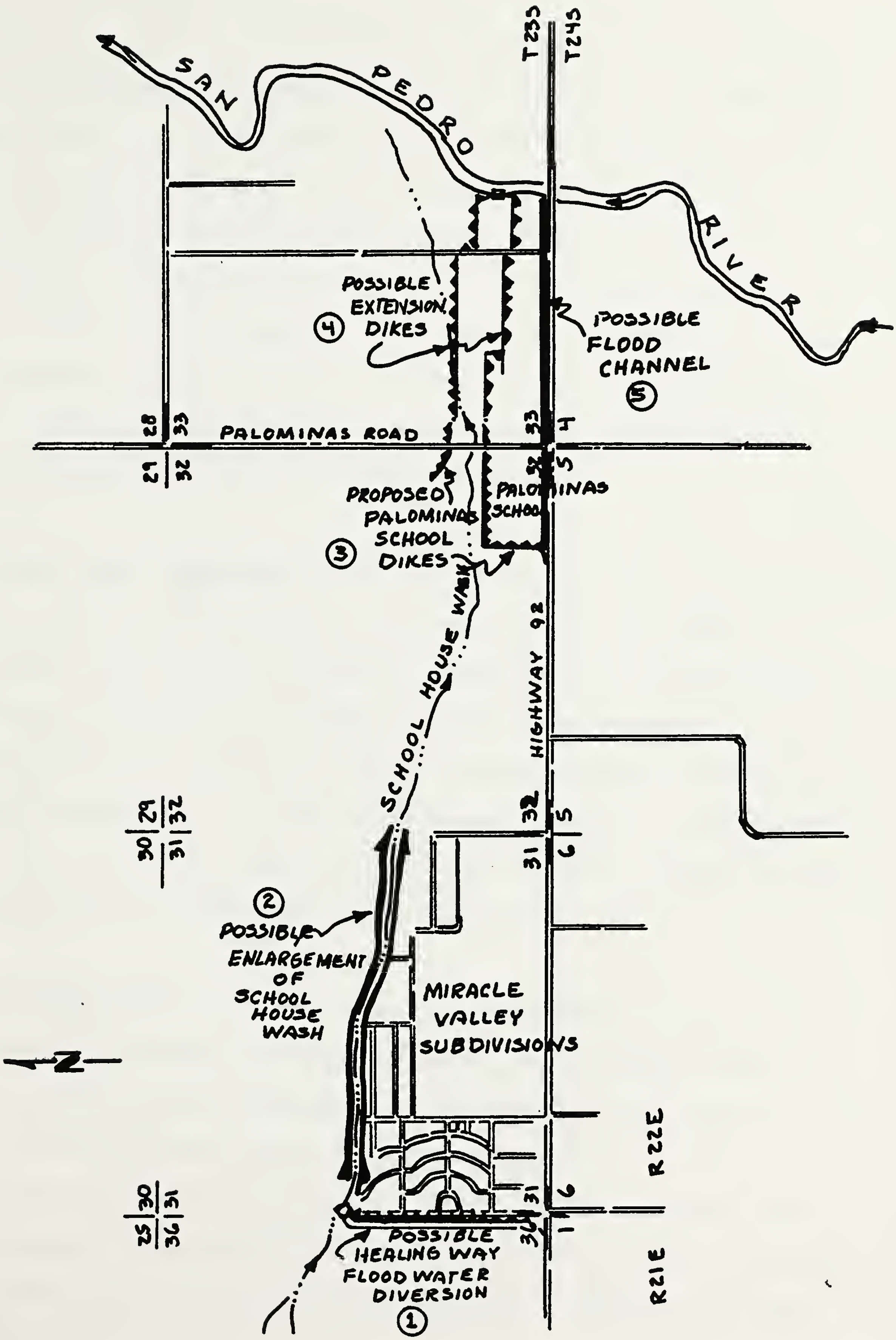


Figure 9
Structural Alternatives Considered

Healing Way Floodwater Diversion--This part of the system would divert local runoff, originating upstream from the Miracle Valley Subdivisions, to the north into School House Wash. It would protect a large part of the subdivision especially in the western portion. An earthen channel was examined with a bottom gradient to match that of the School House Wash at the point of outlet. As an alternate, a dike was considered to divert the flows with a grouted rock chute structure to lower the flows into School House Wash. Comparing benefits to costs it appears that the benefits may not support the cost of either type of structure component.

School House Wash--The decreasing ability of this channel to convey floodwater as the channel proceeds downstream would be corrected by enlargement. A trapezoidal channel following the existing gradient but shaped to stabilize sides and to convey flow at nonerosive velocities was considered. In lieu of channel enlargement a flood wall located along the south bank of School House Wash was also considered. Either structure would protect the northern part of the Miracle Valley Subdivisions throughout their length. The cost of either system could not be justified by the expected benefits.

Palominas School Dikes--This key component of the system would consist of a dike beginning at Highway 92, extend northward along the western edge of the school complex to the north boundary, and then proceed eastward past Palominas Road. A short dike would also be installed on the north side of the School House Wash and extended across Palominas Road to provide protection to the road and houses to the north of the east side of Palominas Road. This system would divert flows that follow along the northside of Highway 92 and those

coming from School House Wash, and place them north of the school and adjacent houses. After conveying the flows past Palominas Road, through a battery of culverts, and past nearby residences the flows would follow the present natural route into the San Pedro River. These dikes would vary in height but would be six feet or less.

Protection would be afforded to the school, adjacent homes to the east of the school, and to commercial and other buildings to the southeast.

If appropriate easements from downstream land owners, where the natural flood path and plain exists, could be obtained for minimal costs, this component may have a favorable benefit to cost relationship.

Dikes Extending from Palominas Road to the San Pedro River--This part of the system would be required if the necessary flood easements, described in the previous section could not be acquired. To convey flows to the river, a pair of low dikes (two feet or less) could be installed along the north and the south following field boundaries to lead the water to the river. This would allow use of the floodway area very nearly as present conditions, but would control the flows to a predetermined location at the river. Training dikes could then be used to collect the water and direct it through a drop structure into the San Pedro River channel. Costs would include the low dikes, land rights for the floodway and all structures and the drop structure at the river.

Comparing overall costs of this system, including the Palominas School diking, to benefits conclude that this is not an economically favorable solution.

Flood Channel Parallel to Highway 92--This component would involve constructing a channel that would collect the flows traveling north and parallel to Highway 92 at the upstream (west) edge of the school. The channel would occupy a width between the highway and the school, would be bridged by Palominas Road, and proceed east to the river at a location near the Highway 92 bridge. It would protect most of the school and adjacent developments to the east and southeast of the school.

It became obvious that this system was too costly for the benefits to be achieved.

Although these evaluations were made in a preliminary manner it does not readily appear that a project can be formulated to have an economic efficiency suitable for implementation under current USDA programs. They might be warranted under other conditions of funding and planning criteria and, therefore, should be given further consideration by local interests.

FLOOD HAZARD MAP

A Flood Hazard Map may be found in the packet at the back of this report. The map, on a photo base, shows the 100-year flood area, the location of many of the cross sections used, the elevations of the 100-year flood at five-feet intervals and the areas of shallow flooding where the average depth is one foot or less. These areas of shallow flooding occur in much of the Miracle Valley subdivisions and the areas south of Highway 92.

To complement this map refer to the Technical Appendix. The appendix includes peak flow estimates at several key locations, flood profiles for much of the area, and representative cross-sections showing the 100-year water surface elevations. Some photos are used to show the 100-year flood depth at selected locations.

cfs	cubic feet per second. A unit of water flow.
cross section	A profile of the land surface taken at right angles to the direction of flow; made by measuring the elevation and distance at ground points along the selected line.
drainage area	The area draining into a stream at a given point (also watershed, drainage, catchment basin).
flood	An event where a stream overflows its normal banks.
flood frequency	An expression or measure of how often a flood event of a given size or magnitude should on the average, be equaled or exceeded. For example, a 100-year frequency flood should be equaled or exceeded in size, on the average, only once in 100 years (also recurrence interval, return period).
flood profile	A graph or a longitudinal profile showing the relationship of the water-surface elevation of a flood event to location long a stream or river.

flood proofing — A combination of structural provisions, changes, or adjustments to properties and structures subject to flooding primarily for the reduction or elimination of flood damages to properties, water and sanitary facilities, structures, and contents of buildings in a flood-hazard area.

flood warning — A community or locally based system consisting of volunteers; rainfall, river and other hydrologic gages; hydrologic models or procedures; a communication network; and a community or local flood coordinator responsible for issuing advance information relative to potential flooding.

hydraulics — The science that treats water in motion.

hydrology — The science that deals with the occurrence and behavior of water in the atmosphere on the ground and undergound.

Mi^2 or M^2 — Square miles; a unit of area.

NGVD — National Geodetic Vertial Datum; sea-level datum of 1929, based on leveling surveys of the U.S. Coast and Geodetic Survey.

overland flow — Runoff which flows over the ground surface in a shallow layer as opposed to channelized flow.

peak discharge	The maximum discharge or rate of flow during a flood at a given location.
peak flood elevation	The highest stage or elevation reched by a flood at a given location.
riparian vegetation	The vegetated area and biotic community influenced by high water tables adjacent to streams and surface waters.
routing	Determining the changes in a flood wave as it moves downstream through a flood plain or reservoir.
runoff	That portion of precipitation which contributes to flow in a channel or cross the land surface (excess rainfall).

REFERENCES

1. Federal Emergency Management Agency; Flood Insurance Study, Cochise County, Arizona, Unincorporated Areas; June 4, 1984.

2. Hydrologic Engineering Center, U.S. Army Corps of Engineers; HEC-2 Water Surface Profiles Computer Program; Users Manual, September, 1982.

3. Soil Conservation Service, USDA; Technical Release No. 20, Computer Program for Project Formulation Hydrology; May, 1983 (Draft Review).

4. Joseph Clinton; Resident of Palominas, Arizona; March, 1987.

5. Jac Hein; Early Sierra Vista; It's People and Neighbors; 1983.

6. Floodplain Board of Cochise County; Floodplain Regulations for Cochise County, AZ; July, 1984.

7. James H. Eychaner, U.S. Geological Survey; Estimation of Magnitude and Frequency of Floods in Pima County, Arizona, with Comparisons of Alternative Methods; Water Resources Investigations Report 84-4442, prepared in cooperation with Pima County and City of Tucson; August, 1984.

8. National Weather Service, NOAA, USDC; NOAA Atlas No. 2, Precipitation-Frequency Atlas of the Western United States, Volume VIII, Arizona; 1973.

9. Soil Conservation Service, USDA; Urban Floodwater Damage Economic Evaluation (URB1) Computer Application Program; January, 1982 (Draft).

ELEVATION REFERENCE MARKS

February 1986

MAP IDENTIFICATION NUMBER	SURVEYOR's IDENTIFICATION NUMBER	DESCRIPTION	ELEVATION
1.	A-1	#5 Rebar; 15' north and 15' west of fence corner approximately 1000' southwest of corner of Sections 36, 31, 1 & 6.	4378.96
2.	A-2	ADOT Cap; on Highway 92 @ intersection of Sections 36, 31, 1, & 6; T23 & 24S; R21 & 22 E.	4368.02
3.	A-3	Pk. Nail; on Highway 92, 4' S of north edge of pavement, 33.5' south of fence corner; SE corner of SW 1/4 SW 1/4 of Section 31.	4346.72
4.	A-4	Pk. Nail; on Highway 92; 4' north of south edge of pavement, 84' north of fence corner near S 1/4 corner Section 31.	4328.98
5.	A-5	Pk. Nail; on Highway 92; 4' south of north edge of pavement, 83.5' south of fence corner; near SE corner of SW 1/4, SE 1/4, Section 31.	4313.59
6.	A-6	ADOT Cap; Highway 92; cap in range box, 0.45' below surface, centerline of highway corner of Sections 31, 32, 6 & 5.	4298.53
7.	A-7	Pk. Nail; Highway 92; 4'south of north edge of pavement; 5.5' south of mile post 339; near SE corner of SW 1/4 , SW 1/4, Section 32.	4286.81
8.	A-8	Pk. Nail; Highway 92; 4' north of south edge of pavement, 83.5' north of fence corner near S 1/4 corner Section 32.	4268.86
9.	A-9	Pk. Nail; Highway 92; 4' south of north edge of pavement; 84' south of fence corner, 31' southwest of powerpole; near SE corner of SW 1/4, SE 1/4 Section 32.	4257.05

10.	A-10	ADOT Cap; Highway 92 range box, 0.45' below surface @ centerline intersection of Highway 92 and Palominas road; corner of Sections 32, 33, 5 & 4.	4245.59
11.	A-11	Pk. Nail; Highway 92; 4' south of north edge of pavement 32.5' southwest of power pole approx. 210' west of SE corner of SW 1/4, SW 1/4, Section 33.	4236.96
12.	A-12	Pk. Nail; Highway 92, 4' south of northedge of pavement, @ West edge of drive to Hereford Feed, in line with fence to north; near S 1/4 corner Sec. 33.	4225.44
13.	A-13	Pk. Nail;Highwy 92; 4' south of north edge pavement, 82' SSW of fence corner, 79' south of power pole; near SE corner of SW 1/4 SE 1/4 Section 33.	4224.32
14.	A-14	ADOT Cap; Highway 92; in range box 0.45' below surface at highway centerline; corner @ Sections 33, 34, 4 & 3	4224.14
15.	A-15	Pk. Nail; Highway 92; 4' north of south edge of pavement, 42' north of fence; approx. 1200' east of corner of SW 1/4 SW 1/4 Sec. 34.	4227.83
16.	A-16	Pk. Nail; Gravel road; north side of Highway 92, 64' south of fence, near S 1/4 corner Section 34.	4284.21
17.	B-1	Alum Cap; 5' west of 8" steel fence corner, near center of NW 1/4 Section 4.	4229.25
18.	B-3	Alum Cap; 45' ± southeast of powerpole, 60' ± southeast of fence corner, near NW corner SW 1/4, SW 1/4 Section 4	4235.87
19.	B-6	Alum Cap; 50' ± west of road, 25' ± northwest of power pole halfway up east slope of 25' ± hill; approx. 1000' west of E 1/4 corner Section 4.	4277.99

20.	C-1	Alum Cap; 25' south of large bush in fence line; approx. 400' west of E 1/4 corner Section 36.	4371.24
21.	C-2	Alum Cap; 15' south of fence in line with west edge of gravel road to south; north of School House Wash; near NE corner of NW 1/4, SW 1/4 Section 31.	4346.96
22.	C-3	Alum Cap; 15' south of School House Wash, 15' east of Gravel Road; approx. 100' south of center of Section 31.	4328.46
23.	C-4	Alum Cap; North edge of gravel street; approx 320' south of NE corner of NW 1/4, SE 1/4 Section 31.	4315.80
24.	C-5	Alum Cap; 5' north of gate post, 18' east of fence corner; near west 1/4 corner Section 32.	4302.02
25.	C-6	#5 Rebar; 5' north of large wood fence post; near NW corner of NE 1/4, SW 1/4 Section 32.	4287.81
26.	C-7	#5 Rebar; 5' north of large wooden fence post 200' ± east of gate; near center of Section 32.	4271.54
27.	C-8	Broken yellow cap on #4 Rebar; projecting 0.45' above surface, near NE corner of NW 1/4, SW 1/4 Section 32.	4257.60
28.	C-9	Pk. Nail; on Palominas Road; 31 west of east edge of pavement at approx. centerline of gravel road to East; near West 1/4 corner of Section 33.	4245.34
29.	C-10	Alum Cap; 12' east of fence corner, 3' south of dirt road, 85' ± northwest of NW corner of metal hay barn; NE corner of NW 1/4, SW 1 4 Section 33.	4235.43
30.	C-11	Alum Cap; 5' north and 6' east of fence corner near W 1/4 corner of Section 34.	4208.96
31.	C-12	Alum Cap;set low on mound 14' north and 16'east of fence corner; approx. 1220'east of W 1/4 corner	

		of Section 34.	4216.08
32.	C-13	Alum Cap; on edge of terrace; approx. 500' north and 300' west of center of Section 34.	4264.42
33.	C-16	#5 Rebar; 22' north of fence corner; approx. 1150' east of SW corner Section 27.	4201.42
34.	C-17	#5 Rebar; 65' ± west of 7' diameter cottonwood tree, 15' SSE of fence; 165.7' north east of corner Sections 26, 27, 33, 34.	4203.58
35.	C-18	#5 Rebar; 12' north of east wire gate post' ± east of fence corner; approx. 1060' west of SE corner Section 28.	4206.80
36.	C-19	Alum Cap; in ditch on north side of Boundary Road 8' south of fence corner; near S 1/4 corner of Sec. 28.	4210.84
37.	D-1	Alum Cap; 6' east of power pole in fence line at edge of King's Ranch Road, approx. 1000' north of corner of Sections 26, 25, 35, 36.	4450.91
38.	D-2	#5 Rebar; 6' north of gravel driveway, approx. 1000' north and 900' east of corner of Sections 26, 25, 35 and 36.	4437.56
39.	D-3	#5 Rebar; 10' east of fence corner, approx. 1000' north of S 1/4 corner of Section 25.	4409.10
40.	D-4	Alum Cap; approx. 1000' north and 1050' west corner of Sections 25, 30, 36 and 31.	4388.27
41.	D-5	Alum Cap; 25' south of fence, approx. 900' west corner of Sections 25, 30, 36 and 31.	4385.34
42.	D-6	#5 Rebar; 50' ± south of 8"x8"x5' fence post approx. 1350 east of corner of Sections 26, 25, 35 and 36.	4429.23
43.	D-7	#4 Rebar; Ranch Road; near corner of Sections 26, 25, 35 and 36.	4450.83

TECHNICAL APPENDIX

INVESTIGATIONS AND ANALYSES

Hydraulic and hydrologic studies were performed to derive water surface elevation-frequency estimates. The results were plotted on cross sections and, subsequently used for mapping flood boundaries. These data also were used to estimate flood depths and resulting damages. Field examinations were also made to assess natural flood plain values.

Hydraulic Studies

The basic field survey data were acquired by photogrammetric methods. This work, performed in 1986, provided topogrophic maps at a scale of 1"=100' (1:1200) with a contour interval of 2 feet. This mapping also was used to obtain cross section and profile data and plottings.

Roughness coefficients were estimated and mapped in the field. The path of low flows were also examined and mapped out as best possible.

Hydraulic computations were made using the U.S. Army Corps of Engineers computer program HEC-2, Water Surface Profiles (Reference 2). The output from this analysis provided the basic rating relationship (elevation-discharge) for each cross section.

Hydrologic Studies

There are no streamflow data for the streams on the alluvial plain. There is a stream gauging station for the San Pedro River

at the Highway 92 bridge. This station is operated by the US Geological Survey and is identified as number 09470500, San Pedro River at Palominas. The peak flow-frequency relationship contained in Water-Resources Investigations Report 84-4142 was used in this study (Reference 7).

The Soil Conservation Service rainfall-runoff simulation model, TR-20 (Reference 3) was used to estimate peak flow-frequency relationships for those streams on the alluvial plain area. The following input data, taken from the listed sources, were developed for use in the computer program:

Input Data	Source
Drainage areas	USGS 7.5 minute quadrangle sheets and the 1:1200 topographic maps developed for this study.
Hydrologic soil-cover complexes (curve numbers)	Soils mapping data was taken from existing surveys made by the Soil Conservation Service (SCS) on file in the Douglas Field Office. Supplementary soil mapping was performed in 1986 by SCS personnel to provide the remaining data needs. Range site surveys and mapping was also done by SCS personnel in 1986 to provide cover and land use data.

Time of concentration	These estimates were made using profiles plotted from USGS 7.5 minute quadrangle sheets and approximate hydraulic parameters of channel cross sections. The study results from the hydraulic analyses were used to estimate travel times in the lower part of the watershed.
Precipitation	NOAA Atlas No. 2 Volume VIII-Arizona (Reference 8).
Channel flood routing	HEC-2 output ratings of elevation-discharge-area for selected cross sections, taken from the hydraulic study results.
Storm Distribution	The Type IIA distribution presented in TSC TECHNICAL NOTE-HYDROLOGY-PO-2. A 24-hour duration storm considered to give the most appropriate intensities for time periods less than 24 hours.

The annual peak flow estimates, resulting from the TR-20 analyses, for selected recurrence intervals and locations are shown in Table 1. These represent the best estimates for present conditions.

Following Table 1 and complementary to the peak flow estimates are (1) floodwater surface profiles for the 100-year flood on the better defined streams; (2) representative cross sections

showing the 100-year water surface and (3) photos showing estimated 100-year flood depths at selected locations.

Damage Studies

Damage analyses were made to assess the need and opportunity to take action in reducing the hazards of flooding. Output from the hydraulic and hydrologic studies were used in the URB1 computer program (Reference 9) to compute flood depth and damage estimates.

The Office of Flood Plain Administrator, Cochise County, provided building value data and estimates of height from ground to first floor for each building. Ground elevations near each building were determined during the aerial mapping using photogrammetric techniques.

General damage coefficients were taken from data provided by Soil Conservation Service and Corps of Engineers sources. Site-specific data for the study area, normally developed from damage interviews, were not developed.

Inventory of Natural Food Plain Values

Mapping units were defined and used as a basis for making field inventories of wildlife resources. A data search was made to inventory and describe historic and prehistoric resources. Refer to the narrative description of the report for information on the units and the map at the back of the report for results.

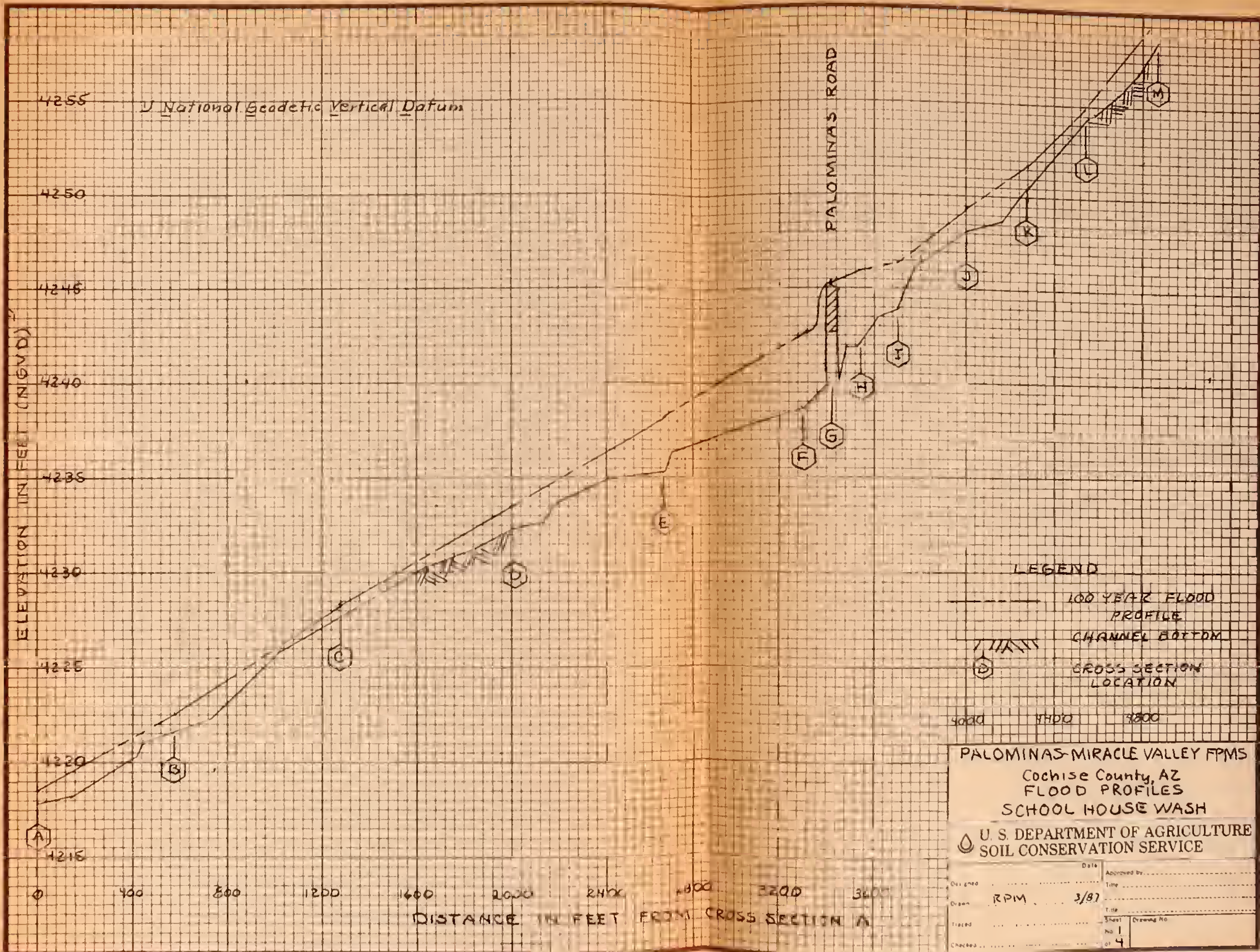
TECHNICAL TABLE

Following is a tabulation showing the estimates of annual peak flows for selected average return periods and locations.

Table 1 - Peak Discharge Estimates

Flooding Source and Location	Drainage Area (Mi^2)	Annual Peak Discharge (cfs) 10-year	50-year	100-year	500-year
School House Wash					
West edge of Mir. Valley	5.15*	720	1460	1820	2720
Leaving Miracle Valley Sub.	6.23*	820	1650	2020	2910
At Palominas School	6.60*	670	1420	1780	2640
Entering San Pedro River	6.87*	650	1410	1770	2700
Drainage North of Highway 92					
Leaving Miracle Valley Sub.	0.75*	190	380	480	700
At Palominas School	2.23*	190	370	470	690
Drainage South of Highway 92					
West edge of Mir. Valley	1.07*	160	370	470	750
Near edge of Mir. Valley	1.23*	40	80	100	150
Entering San Pedro River	1.25*	130	220	260	360
San Pedro River					
At Highway 92 Bridge	741	13,000	19,400	22,300	29,500

*These flows are affected by upstream overflows out of the water course.



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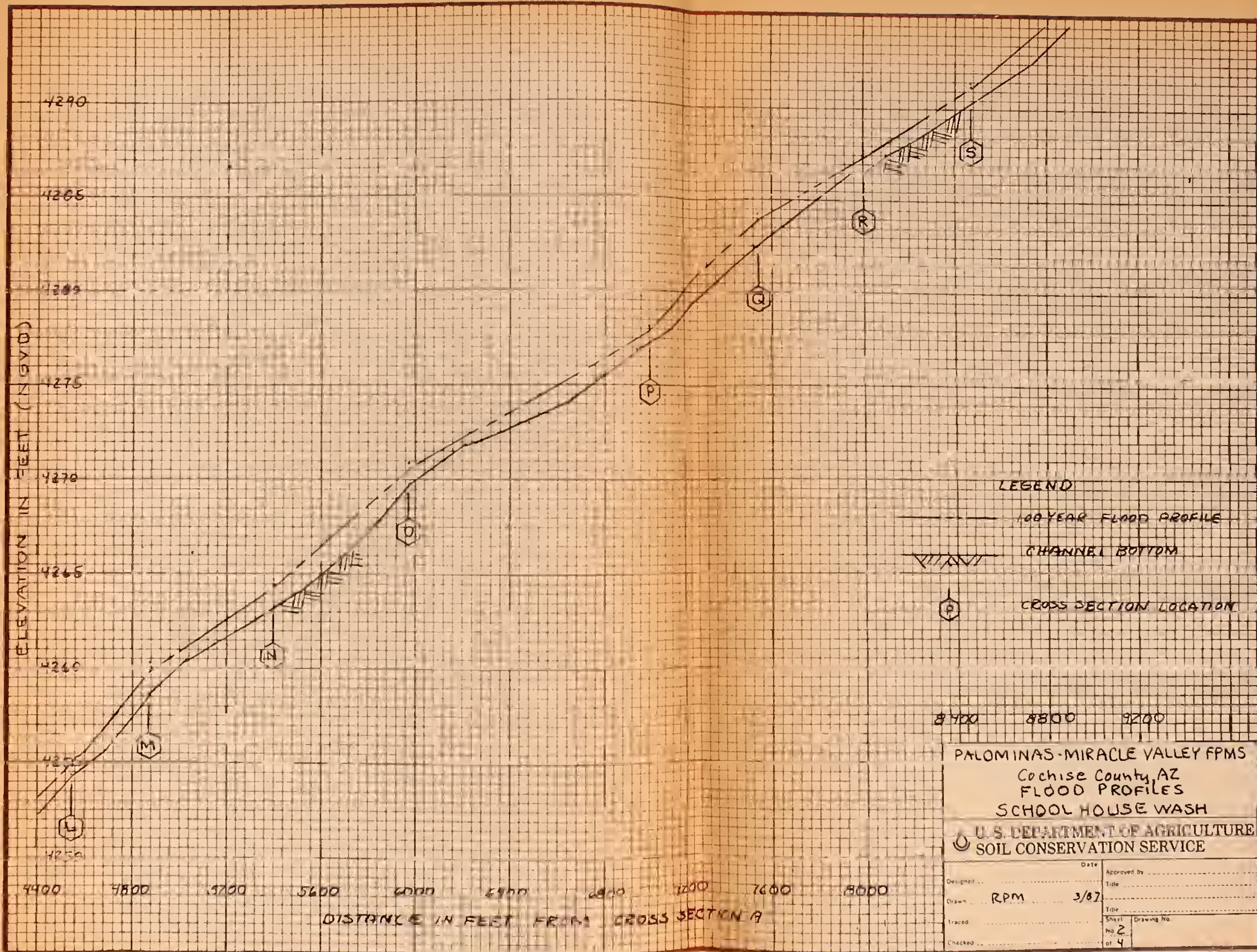

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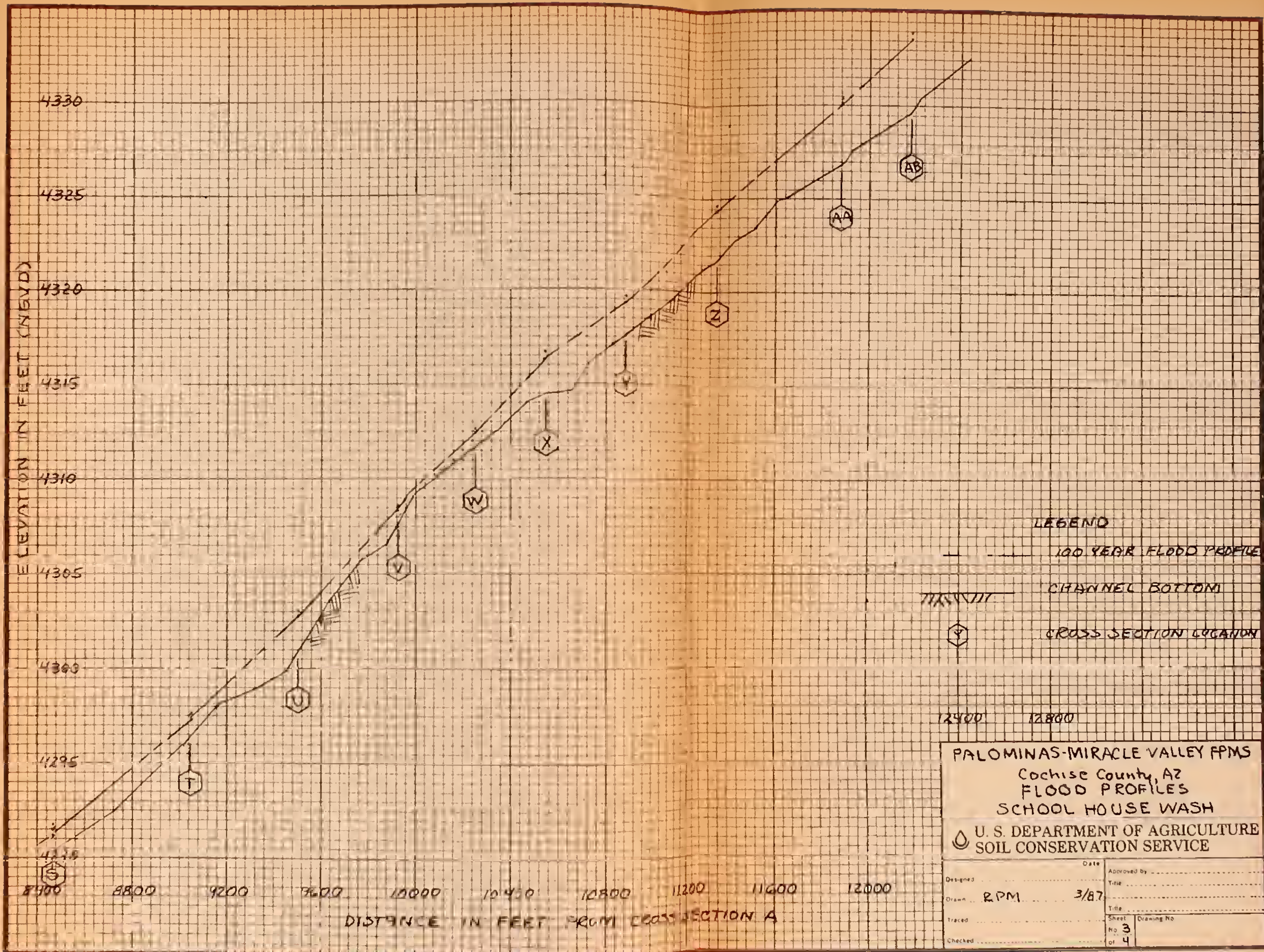
Fold-out Placeholder

This fold-out is being digitized, and will be inserted at a future date.



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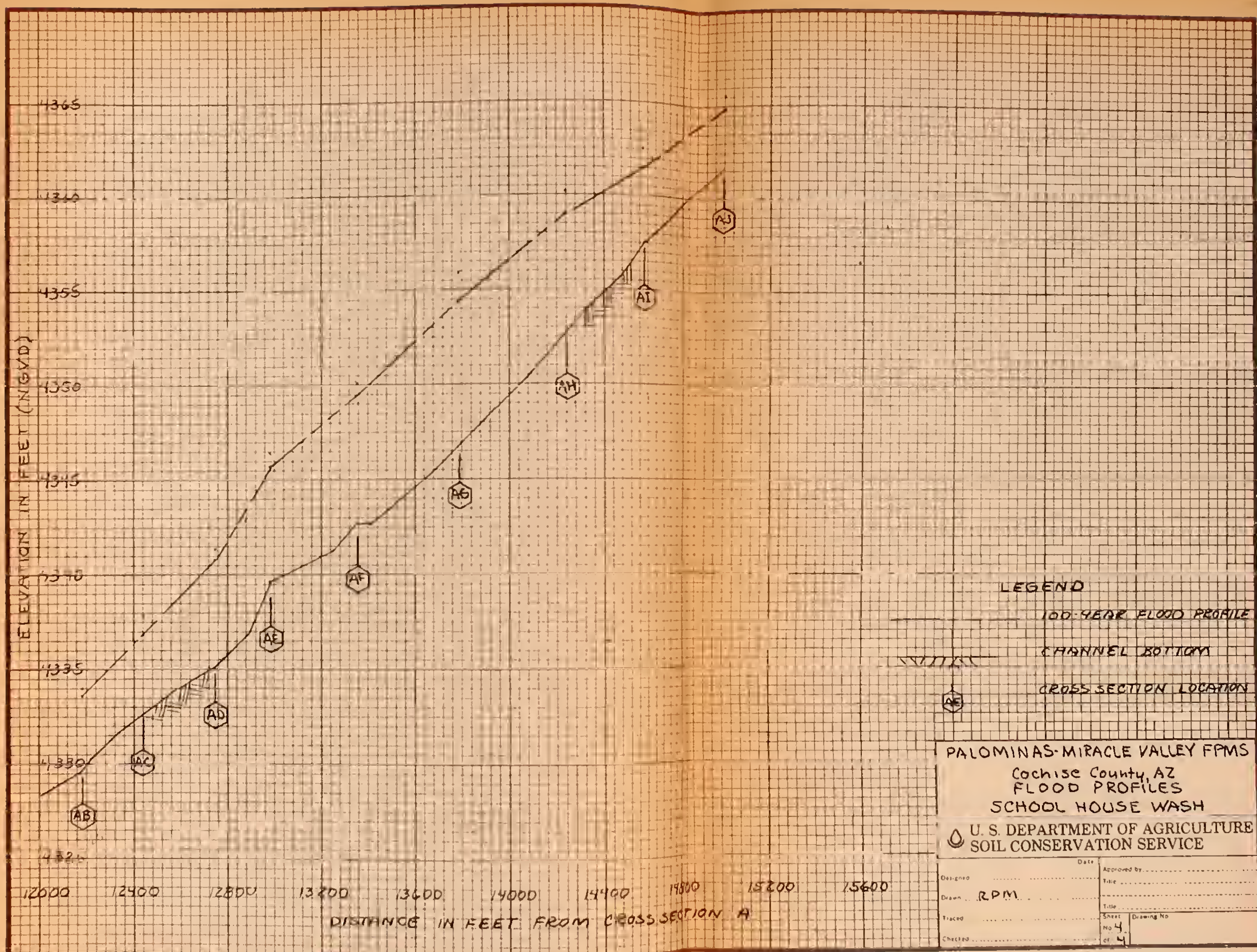
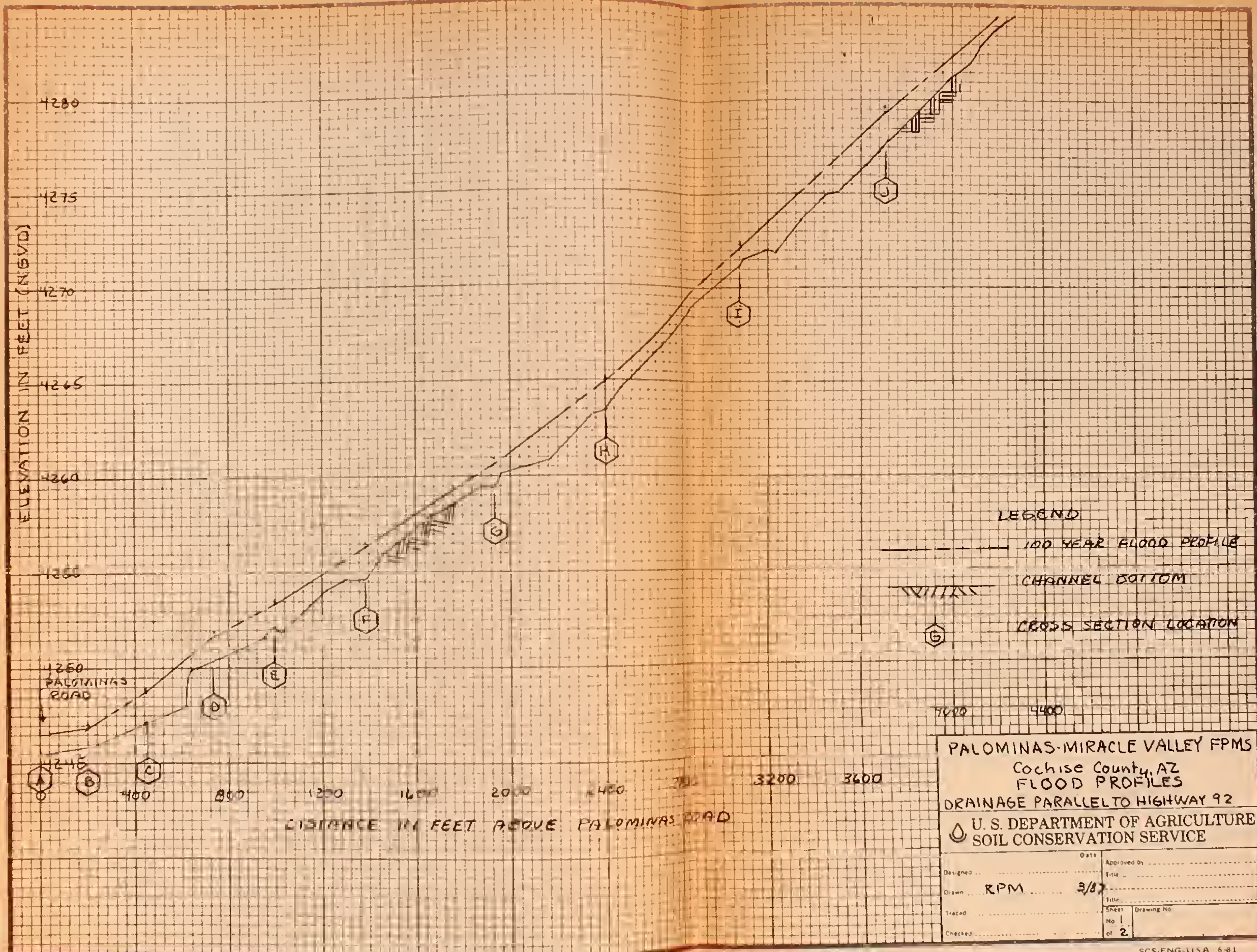
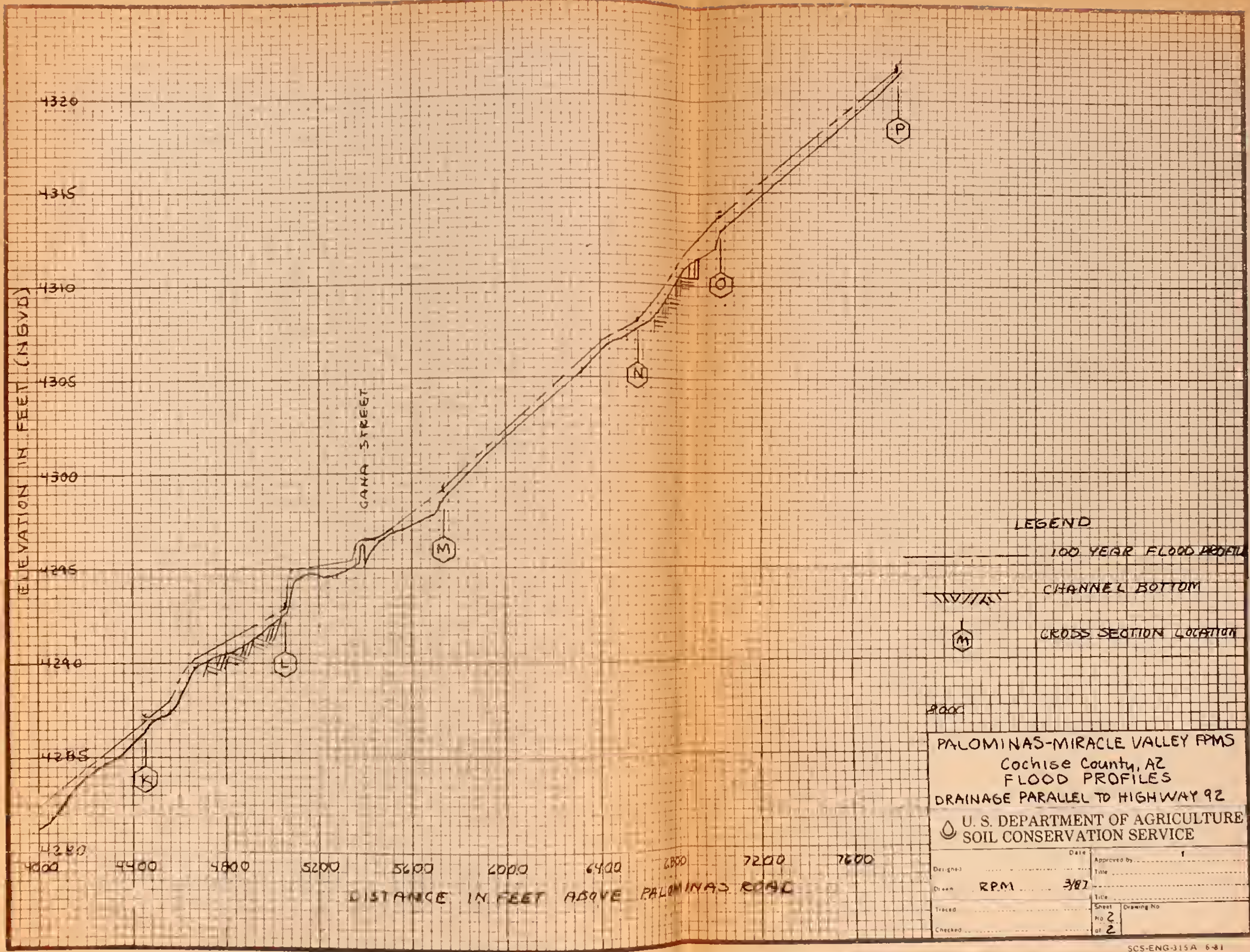

ELEVATION IN FEET (NGVD)
4365
4360
4355
4350
4345
4340
4335
4330
4325
12000
12400
12800
13200
13600
14000
14400
14800
15200
15600
DISTANCE IN FEET FROM CROSS SECTION A
AB
AC
AD
AE
AF
AG
AH
AI
AJ
LEGEND
100-YEAR FLOOD PROFILE
CHANNEL BOTTOM
CROSS SECTION LOCATION
PALOMINAS-MIRACLE VALLEY FPMS
Cochise County, AZ
FLOOD PROFILES
SCHOOL HOUSE WASH
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Drawn RPM
Sheet No 4 of 4
SCS-ENG-315A 6-81


ELEVATION IN FEET (NGVD)
4280
4275
4270
4265
4260
4250
PALOMINAS ROAD
4245
400
800
1200
1600
2000
2400
3200
3600
4000
4400
DISTANCE IN FEET ABOVE PALOMINAS ROAD
LEGEND
100 YEAR FLOOD PROFILE
CHANNEL BOTTOM
CROSS SECTION LOCATION
PALOMINAS-MIRACLE VALLEY FPMS
Cochise County, AZ
FLOOD PROFILES
DRAINAGE PARALLEL TO HIGHWAY 92
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Drawn RPM 3/87
Sheet No 1 of 2
SCS-ENG-315A 6-81



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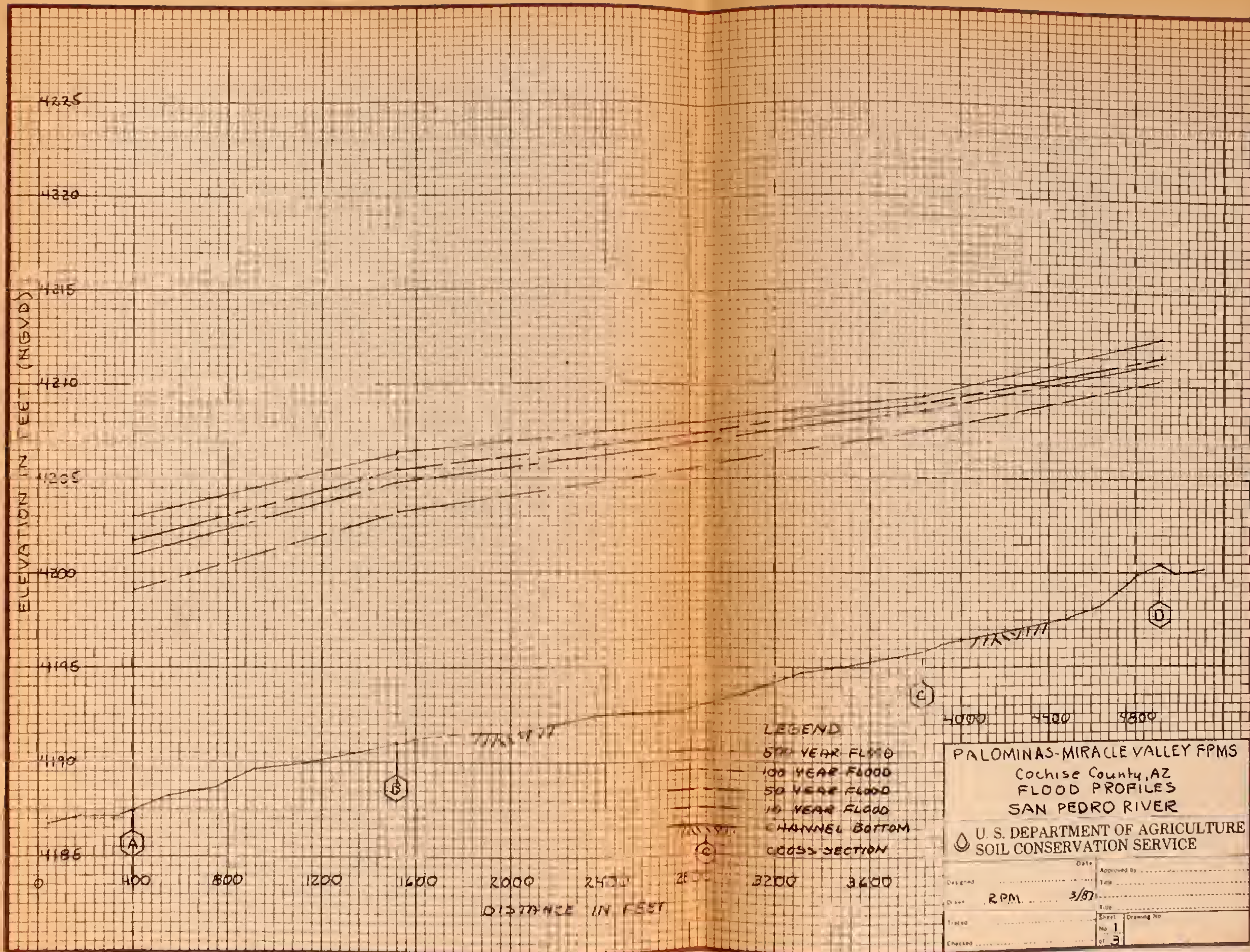

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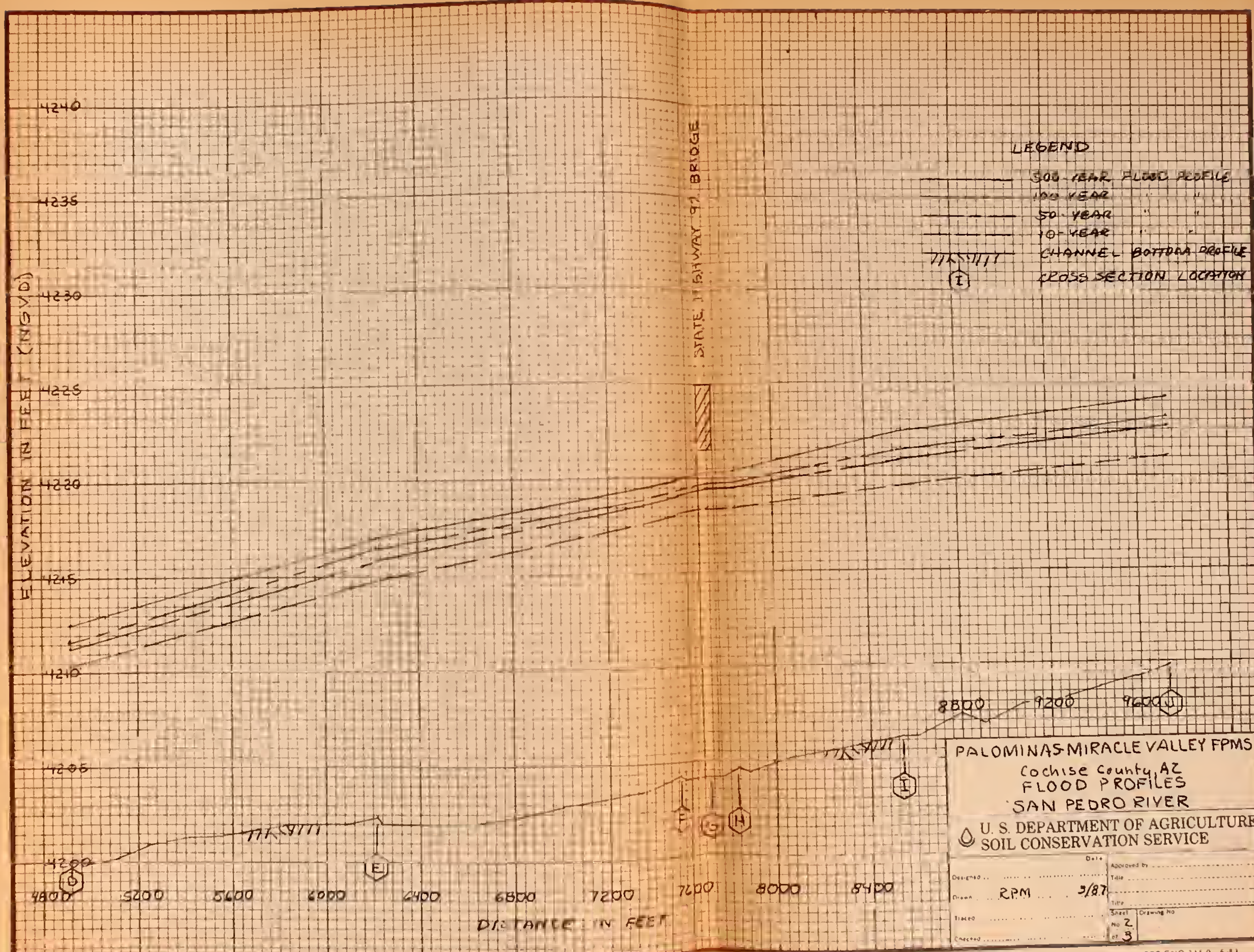
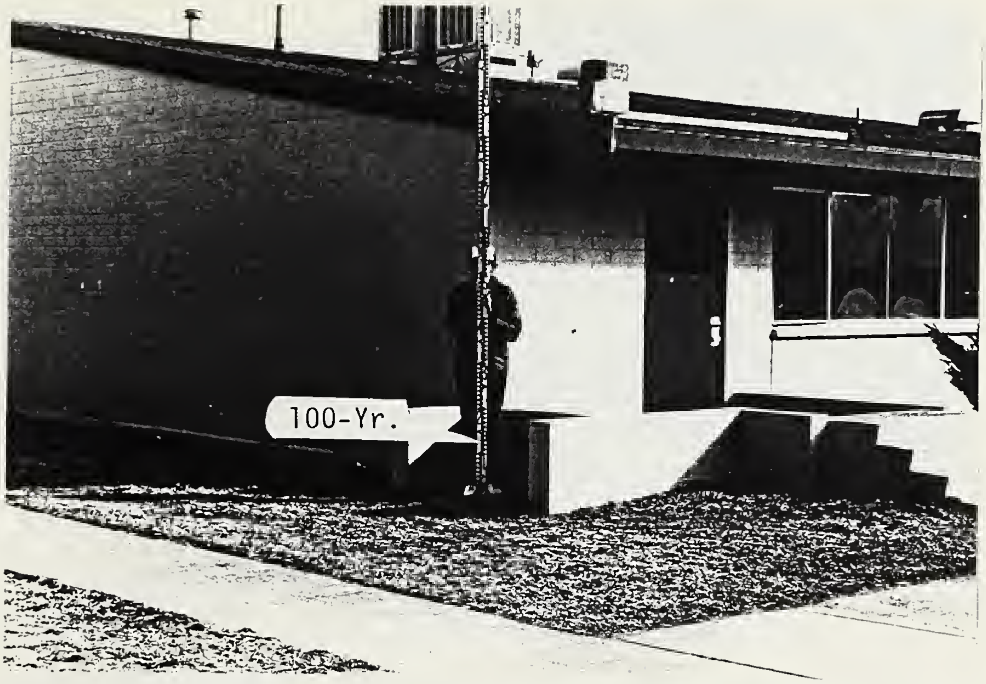

ELEVATION IN FEET (NGVD)
4240
4235
4230
4225
4220
4215
4210
4205
4200
STATE HIGHWAY 92 BRIDGE
LEGEND
500-YEAR FLOOD PROFILE
100-YEAR "
50-YEAR "
10-YEAR "
CHANNEL BOTTOM PROFILE
CROSS SECTION LOCATION
4800
5200
5600
6000
6400
6800
7200
7600
8000
8400
8800
9200
9600
DISTANCE IN FEET
D
E
F
G
H
I
J
PALOMINAS-MIRACLE VALLEY FPMS
Cochise County, AZ
FLOOD PROFILES
SAN PEDRO RIVER
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
RPM
3/87
Sheet No 2 of 3
SCS-ENG-315A 6-81

Along Healing Way Road between Second and Third Avenue looking east. Depth, 1.0 ft.

Near Fourth Avenue along Loaves and Fishes Street, looking south. Depth, 0.5 ft.

House on north side of School House Wash near junction of Third Avenue and the Wash, looking northeast. Depth, 0.7 ft.

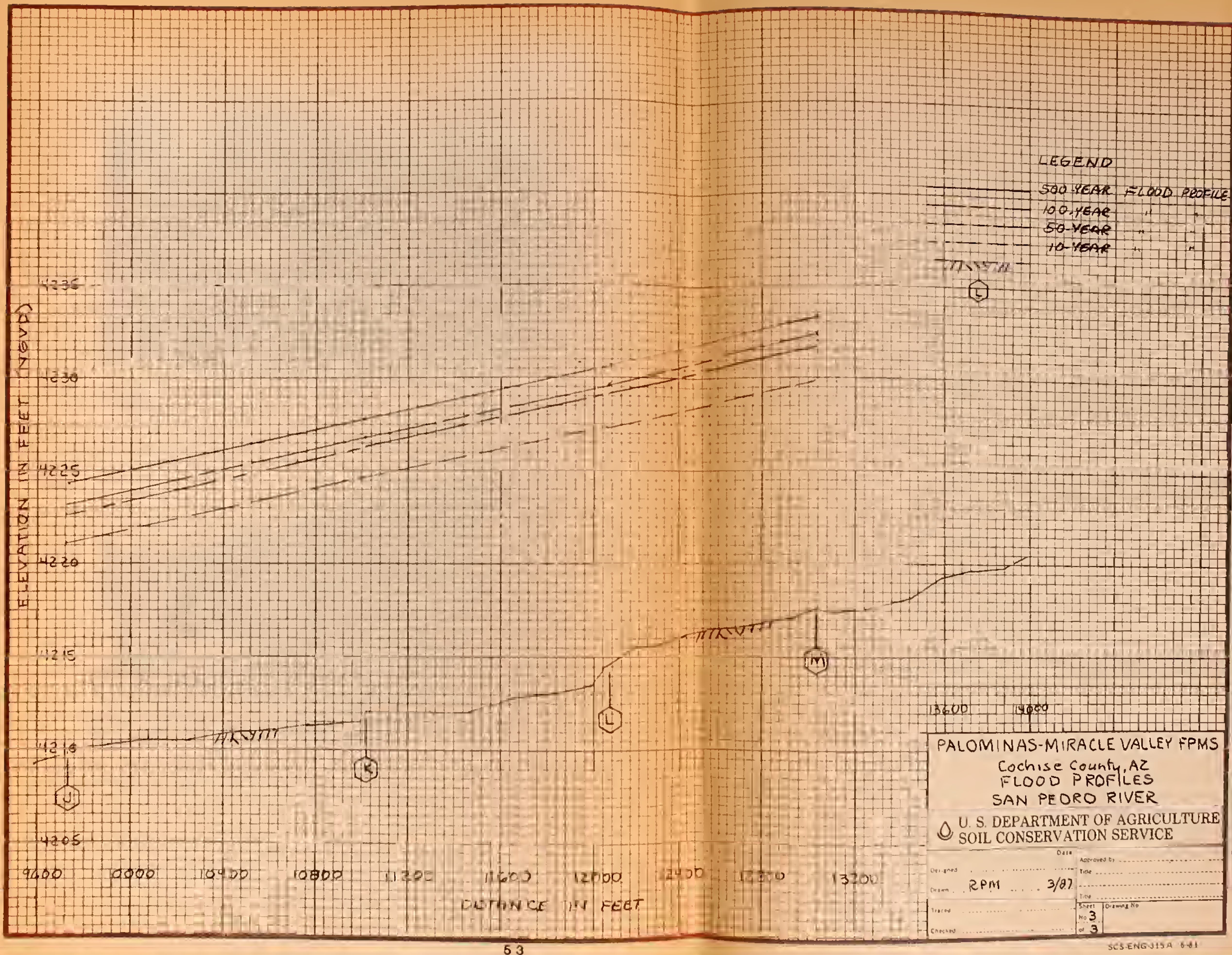
House on south side of School House Wash near junction of Third Avenue and the Wash, looking southeast. Depth, 1.3 ft.

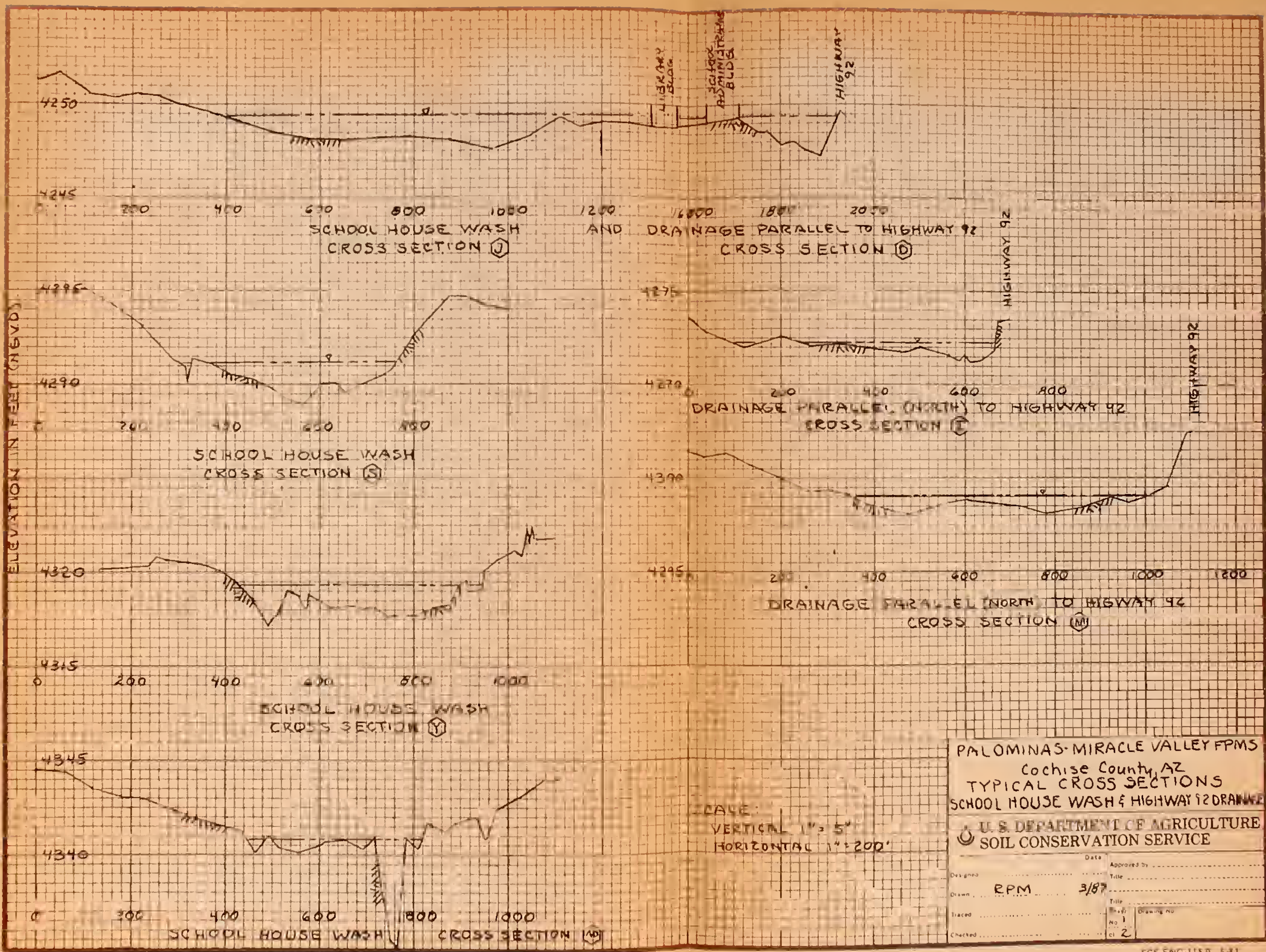


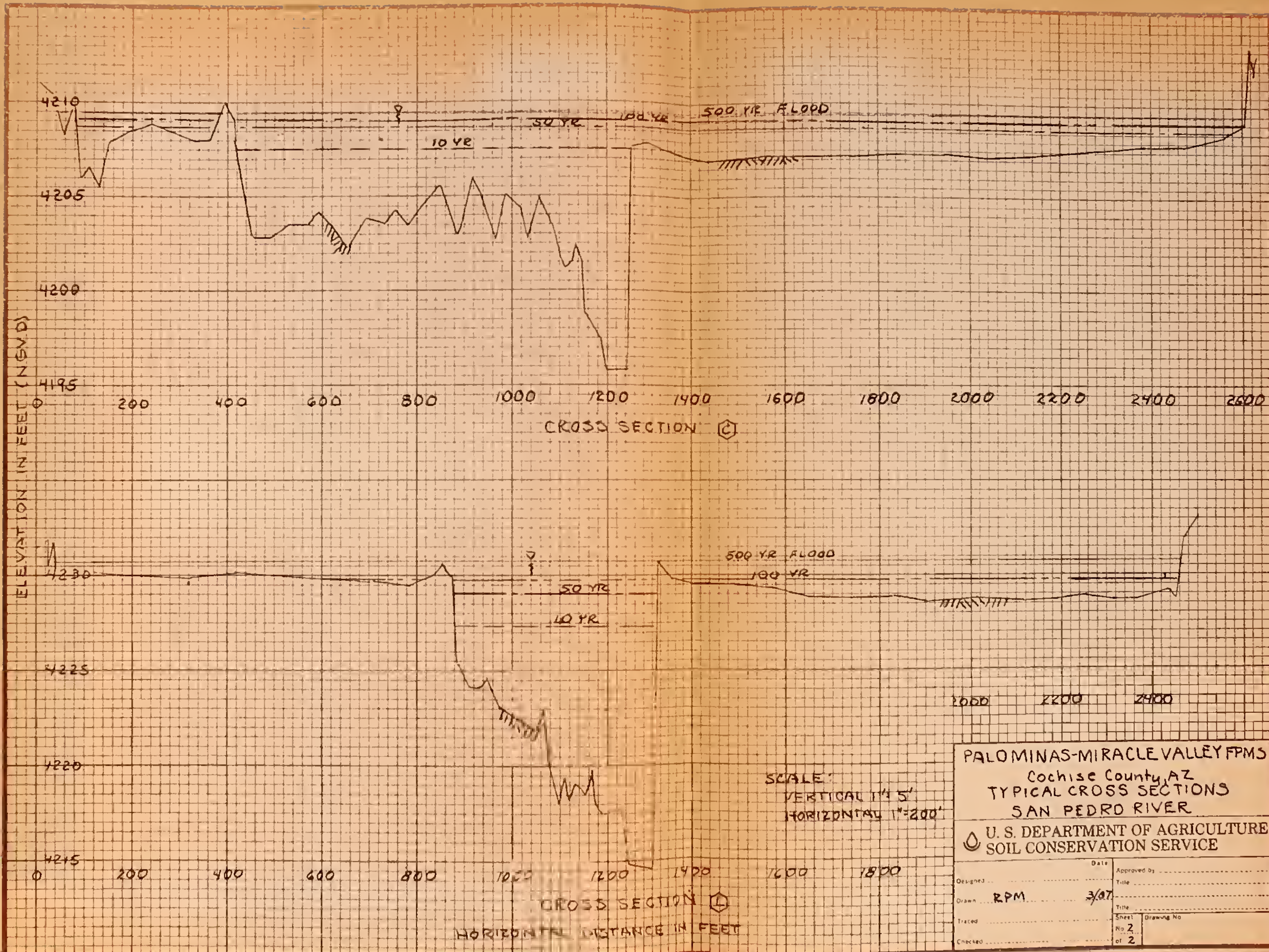
Junior High Building, Palominas School Complex, looking northeast. Depth, 1.2 ft.

Library Building, Palominas School Complex, looking west. Depth, 0.9 ft.

Special Education and 5th Grade Building, Palominas School Complex, looking northeast. Depth, 0.5 ft.


LEGEND
500 YEAR FLOOD PROFILE
100-YEAR " "
50-YEAR " "
10-YEAR " "
ELEVATION IN FEET (NGVD)
4235
4230
4225
4220
4215
4210
4205
9600
10000
10400
10800
11200
11600
12000
12400
12800
13200
13600
14000
DISTANCE IN FEET
J
K
L
M
PALOMINAS-MIRACLE VALLEY FPMS
Cochise County, AZ
FLOOD PROFILES
SAN PEDRO RIVER
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed
Date
Approved by
Title
Drawn RPM 3/87
Traced
Checked
Sheet No 3 of 3
Drawing No
SCS-ENG-315A 6-81


ELEVATION IN FEET (NGVD)
LIBRARY BLDG.
HIGHWAY 92
SCHOOL HOUSE WASH
CROSS SECTION (J)
AND
DRAINAGE PARALLEL TO HIGHWAY 92
CROSS SECTION (D)
SCHOOL HOUSE WASH
CROSS SECTION (S)
DRAINAGE PARALLEL (NORTH) TO HIGHWAY 92
CROSS SECTION (E)
SCHOOL HOUSE WASH
CROSS SECTION (Y)
DRAINAGE PARALLEL (NORTH) TO HIGWAY 92
CROSS SECTION (M)
SCHOOL HOUSE WASH CROSS SECTION (AD)
SCALE:
VERTICAL 1" = 5'
HORIZONTAL 1" = 200'
PALOMINAS-MIRACLE VALLEY FPMS
Cochise County, AZ
TYPICAL CROSS SECTIONS
SCHOOL HOUSE WASH & HIGHWAY 92 DRAINAGE
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Drawn RPM 3/87
SCS-ENG-315A 6-81



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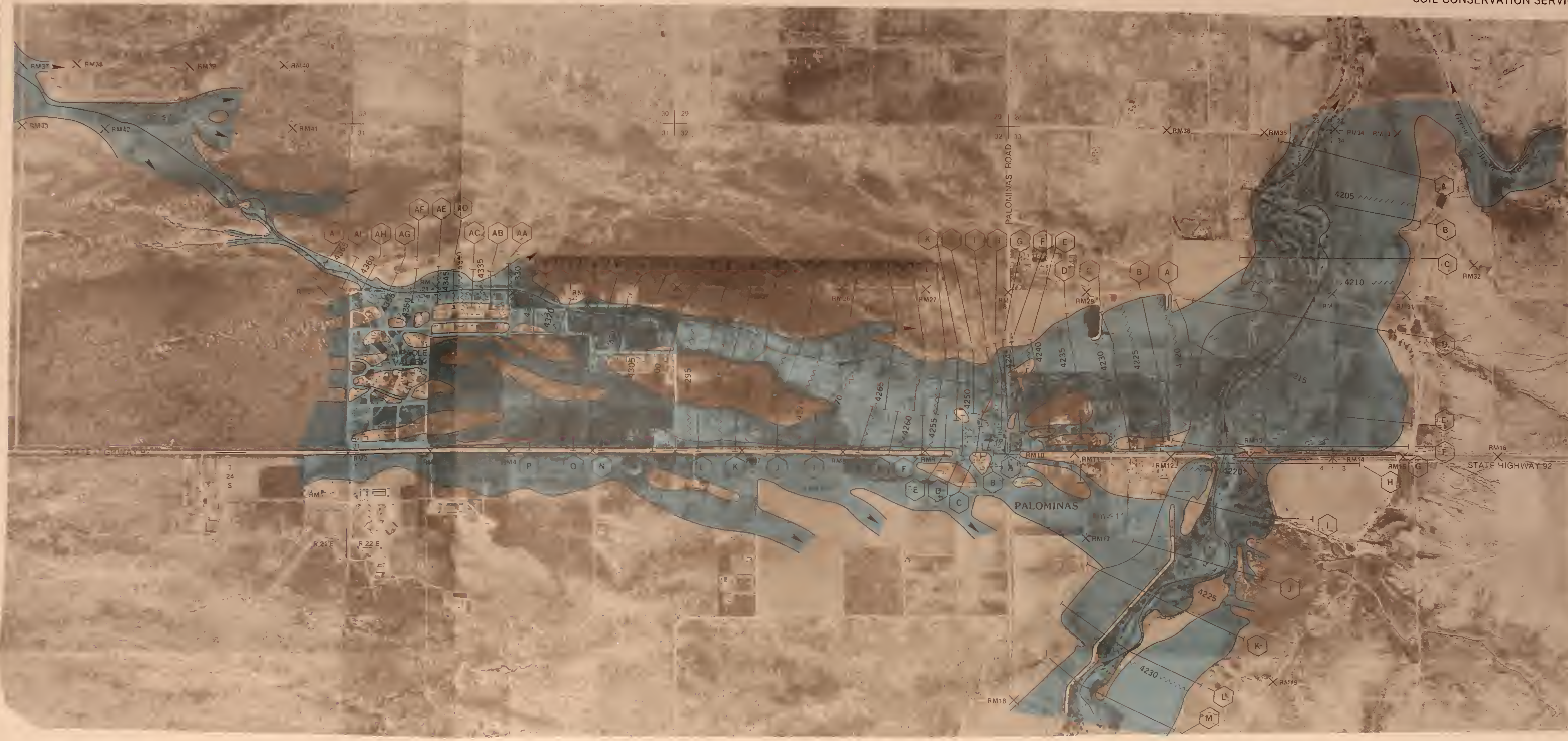
U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE



LEGEND

CROSS SECTION

100 YEAR FLOOD ELEVATION

Dm ≤ 1' AVERAGE DEPTH EQUAL OR LESS THAN ONE FOOT

INUNDATED AREA, 100 YEAR FLOOD

RM1 ELEVATION REFERENCE MARK

NOTE: MAP WAS PREPARED TO PROVIDE MINIMUM FLOOD PLAIN MANAGEMENT INFORMATION. IT MAY NOT SHOW ALL AREAS SUBJECT TO FLOODING.

DATE OF PHOTOGRAPHY FEBRUARY 1986

FLOOD HAZARD AREA

PALOMINAS-MIRACLE VALLEY AREA FLOOD PLAIN MANAGEMENT STUDY

COCHISE COUNTY, ARIZONA

BY THE
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MARCH 1987

SCALE 0 1000 2000 FEET
0 200 400 600 METERS
APPROXIMATE

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

MAPPING UNITS

(1) RIPARIAN AREA

(2) CROPLAND (ACTIVE)

(3) CROPLAND (ABANDONED)

(4) NATIVE RANGELAND

(5) RURAL BUILTUP AREA

PRIME FARMLAND

N

DATE OF PHOTOGRAPHY FEBRUARY 1986

INVENTORY OF NATURAL VALUES
PALOMINAS-MIRACLE VALLEY AREA
FLOOD PLAIN MANAGEMENT STUDY
COCHISE COUNTY, ARIZONA

BY THE
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MARCH 1987

SCALE 0 1000 2000 FEET
0 200 400 600 METERS
APPROXIMATE

AUGUST 1987 4 R 40130